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ET Docket 98-153

In the Matter of
Revision of Part 15 of the Commissions' Rules
Regarding Ultra-Wideband Transmission Systems

Comment on Notice of Proposed Rulemaking
FCC 00-163 adopted: 05/10/00

To: **The Commission**
Comments of: **Æther Wire & Location, Inc.**

Summary:
We propose that operation of unlicensed Ultra-Wideband devices be permitted under the general emission limits contained in 47 C.F.R. Section 15.209, with the proviso that UWB devices be included in the exemption for intentional radiators of paragraph (d) of section 15.205. We claim that 3D Relative Position (*i.e.* Localization) is the most useful application for UWB, and that the optimal spectrum for Localization is below 2 GHz. We also claim that society will not enjoy the benefits of small, low-cost, low-power UWB devices for position location and low data rate communication unless such devices are permitted to operate below 2 GHz.

Company Profile:

Æther Wire & Location, Inc. is developing CMOS Integrated Circuits, embedded software, and the localization infrastructure to make low cost, low power, small size localizer products using UWB technology. Our products provides precise relative 3D position location within a network of RF transceivers (Localizers) distributed in the environment. Our technology is capable of localization to *centimeter* accuracy, and unlike GPS, can operate within buildings, urban areas, or forests. Also, our Localizers inherently share position location information throughout the network, while most other localization systems require a separate communication channel.

Æther Wire started our R&D effort using UWB in 1991. We have maintained a long term goal of producing totally integrated transceivers. Therefore, we have designed and built a series of increasingly more capable breadboard / prototype units, using our own custom chips which has given us significant hands-on experience using UWB. With each succeeding prototype generation, the size has shrunk from breadbox, to shoebox, to cellphone, to pager-sized for our fourth generation prototype. At the same time, the resolution and range have improved. The fourth generation units will have at least 1 centimeter resolution with 30–60 meters range.

Æther Wire funding includes three DARPA grants and Venture Capital investment. The company holds several Localizer-related patents, including #5748891 issued in May 1998. Additional company information is available at our Web Site: http://www.aetherwire.com .

 12 September 2000

Applications and General Characteristics:

Two categories of applications are described in the NPRM: *Radar* and *Communications*. There is a third category, ***Localization***, for which UWB is ideal, and which has a myriad of applications. Even though UWB has unique advantages for many radar and communications applications, these categories are currently well served by narrow-band RF. For localization, GPS is only suitable for position location applications that are (a) outdoors, (b) only need 10 – 30 meters resolution, and (c) care about longitude and latitude versus relative location with respect to a person, building, or surroundings.

In the future, our homes and businesses will be filled with cybernetic servants in the guise of everyday things. Their jobs will be to interpret and respond to our needs, and to do so in the least intrusive way. They will mediate human interaction with the Internet in a direct and intuitive manner using sensors and effectors distributed throughout the environment. To be ubiquitous and mobile, these "smart things" must be wireless and capable of determining precise relative position location.

The need for wireless connectivity is obvious. The need for position location is predicated on the fact that once a sensor is wireless, the first data it needs is its existence and its location. Moreover, what is really desired is location relative to other people, objects, or structures, not the absolute position on the geoid that GPS provides. Also, the range and resolution of the position location need to be proportionate to the scale of the objects being located.

Knowing position location can imbue our cybernetic servants with situated awareness. They will be able to react to the mere presence of humans, or to their gestures, movements, or stance. For instance, the lights turn on before a person enters a room. The home or car door unlocks when the owner reaches for the handle. A sudden fall is detected automatically and help summoned.

The embedded computing that will make everyday things smart is riding the curve of Moore's law to becoming cheaper, smaller, and lower power. To dramatically enhance ubiquity and mobility, the wireless component of "smart things" must be equally cheap, small, and low power. For example, a pager-sized device is suitable for finding skiers on the slopes, but tracking patient folders in a hospital or locating books in a library requires a coin-sized tag. A device for finding firemen in a burning building could easily cost $500, but a food container that monitors leftovers in the refrigerator would have to cost less than $5. A sports training system that captures the 3D location of players on the field could be recharged every night, but an inventory monitoring system would need tags that last at least a year.

The following is an abbreviated list of applications which need UWB *Localization* devices. A more detailed description of these applications appears in Exhibits I and II, at the end of this response:

Applications which Require UWB Localization

Public Service and Safety

- Fireman Buddy System
- Home Navigation System for the Blind
- Handicapped / Learning Impaired Tracking System
- House Arrest Monitors
- Automobile Collision Avoidance System
- Waterway Markers (Electronic Buoys)
- Fault Line Detection

Consumer

- Child Finder
- Virtual Fence for Pets and Livestock
- Sports Coaching System
- Passive Keyless Entry Systems for Homes and Car
- Never Lost Products
- Smart-Home Monitors

Industrial

- Mining Equipment Tracking Systems
- Museum Guide
- Virtual Reality Sensors
- Motion pictures

Government/Military

- Roadway Edge Markers for Snowplows
- Military Vehicle and Personnel Location Systems
- Emergency Equipment Markers

Asset Tracking/Inventory Management

- Sea-Tainer Tracking Systems
- Volumetric Inventory Control Systems
- Hospital Equipment and Personnel Location Systems
- Library Book Locator

UWB Companion Applications to Narrow Band Communications / GPS

- E-911 “Last Meter”
- Small Sensor Communication
- Information Spigot for the Wireless Web
- Ground Guidance for Airplanes
- Aiming Directional Antennas and Lasers
- Synthesis of Large Aperture Antennas

Comments in response to specific paragraphs of the NPRM

Footnote 8:

The formula for the 20 dB bandwidth of a "pulsed radar" signal applies for a sinewave carrier modulated by a pulse envelope. As shown in **FIGURE 3**, however, a 0.5 ns Gaussian impulse (50% width) has a 20 dB bandwidth of 1.75 GHz, while the formula $B = 6.36/t$, and the example given, would suggest a bandwidth of 12.72 GHz. This is an over-estimate of 7.3 times. Using the formula $B = 1.79/\sqrt{(t_r t)}$, with $t_r = t = 0.5$ns, gives a bandwidth of 3.58 GHz, an over-estimate of only 2. This factor of 2 can be understood as counting the upper and lower sidebands. A baseband signal like a Gaussian impulse, however, has no lower sideband. Thus the bandwidth of an impulse is actually half of what the 2nd formula shows.

We suggest that the formula $B = 0.895/t$ be used to estimate the bandwidth of a Gaussian impulse from its 50% amplitude (voltage) point.

Paragraph 12:

We agree that UWB can be used for very high data rate communication in severe multipath environments, or where line-of-sight transmission is blocked. What has not been noted is that UWB is inherently well suited for low data rate sensor communication and inventory monitoring. The following introduction is from our successful proposal to DARPA to develop *Integrated, Low-Power, Ultra-Wideband Transceivers for Pervasive Internet Connectivity*.

> The next explosion in growth of the Internet will come from connecting to many cheap, low-power sensors, effectors, and "smart things". This prediction has been made by many futurists and visionaries.[1,2,3] In all their scenarios, the transformative benefits from connecting to the Internet happen when such telemetric systems are mobile and/or on our persons, children, pets, etc. The unstated assumption of this vision is that wireless transceivers will exist which are suitable for connecting to small, cheap, ubiquitous devices — devices which are battery powered and can operate unattended for weeks, months, or years. We claim that integrated CMOS ultra-wideband transceivers (Localizers) with precise 3D position location capability are the enabling technology for this "finest-grained" networking of ubiquitous sensors and effectors.
>
> Compared to sinewave frequency-based transceivers, UWB Localizers inherently can be <u>cheaper</u>, <u>smaller</u>, <u>lower-power</u>, and better <u>able to operate in high multipath environments</u> like buildings. These attributes enable pervasive Internet connectivity, because the cost, size, power, and operating environment of the wireless link must be fractionally proportionate to the items it connects.
>
> Æther Wire's Localizers transmit and receive bursts of ultra-wideband signals consisting of Gaussian ~1 ns impulses. These baseband signals occupy the frequency range from approximately 100 MHz to 1 GHz <u>without</u> any carrier frequency. Ultra-wideband radiation combines the advantages of having gigahertz bandwidth and using low frequencies. Gigahertz

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1 Neil Gross, "21 Ideas for the 21st Century: Internet", *Business Week*, pp. 132-134, August 30, 1999.

2 Paul Saffo, "Sensors: The Next Wave of Innovation", *Communications of the ACM*, Vol. 40, No. 2, pp. 93-97, February 1997.

3 Janet Wilson, "Toward Things That Think for the Next Millennium", *Computer*, Vol. 33, No. 1, pp. 72-76, January 2000.

bandwidth gives centimeter range resolution for position location, the ability to discriminate multipath signals, and the possibility of high data rate. Operation at low frequencies gives the ability to penetrate walls, and to use slower, cheaper (*i.e.* CMOS) circuits. Also, ultra-wideband radiation does not suffer from the deep fading nulls (~30 dB) that plague sinewave signals in the presence of multipath.

Localizers can be totally integrated in a single CMOS chip, because they require less aggressive technology and no reactive components. Transmission and reception of ultra-wideband signals does not require high-Q inductors nor transistors with f_T's 5 to 10 times the transmission frequency to ensure linearity. Cellular phone manufacturers predict that even a single-chip RF section is nowhere in sight, since multiple technologies (discrete, GaAs, bipolar, and CMOS) are needed for sinewave transmission and reception. Computing and networking are becoming pervasive thanks to Moore's law. The promise of seamless wireless connectivity continues to be elusive because conventional sinewave frequency-based RF cannot take full advantage of Moore's law.

Single chip integration of Localizers contributes to low cost, small size, and low power. Extremely low power consumption ultimately comes from low duty-cycle episodic transmissions, with the minimum power consumption for RF reception set by the thermal noise floor. A network of Localizers can maintain synchronization with very low duty cycle, because Localizers use short (~10 µs) episodic transmissions and very accurate timing (~1 part per billion). This is achieved via a protocol-based consensus clock, even though in a wireless network individual Localizers need only cheap ~1 ppm crystal oscillators.

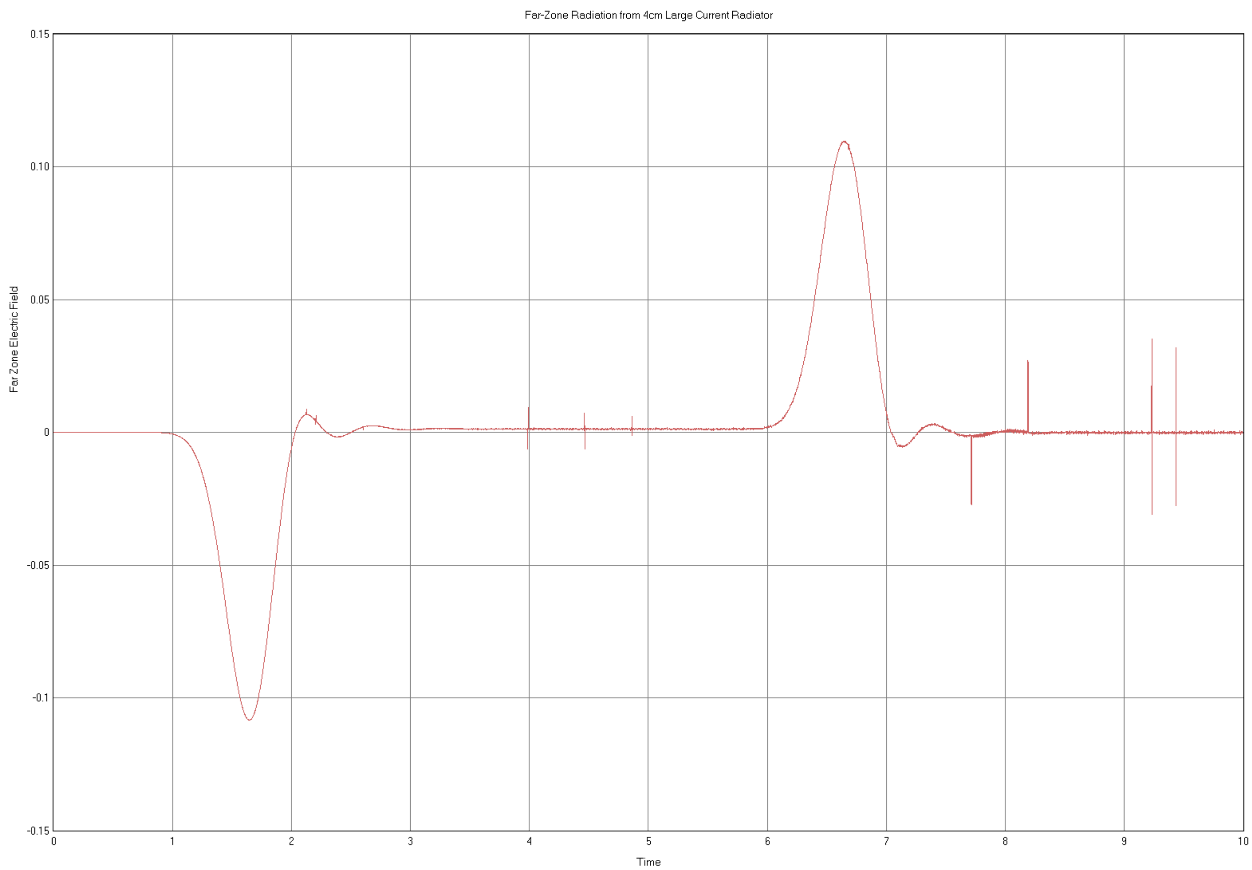

FIGURE 1 Simulated (FDTD) Far-Zone radiation from 4cm Large Current Radiator using 0.5ns Gaussian edges.

Paragraph 13:

We do not agree with Time Domain's categorization of which applications will operate in which range of frequencies. In all cases where the UWB signal needs to penetrate walls, floors, pavement, debris, earth, snow, etc., the use of frequencies below 1 GHz is optimal. A possible rationale for their categorization is that the conventional UWB antennas for signals with frequencies below 1 GHz (*e.g.* a TEM horn) are physically large. The signal waveform (*i.e.* a monocycle) that Time Domain is able to generate using their small antenna does not have low frequency components. Apparently, they are equating low frequency operation with applications that can be physically large, but this is not a limitation dictated by nature. The Large Current Radiator (LCR) is a physically small antenna that is capable of radiating Gaussian impulses with minimal distortion when driven with a Gaussian edge (**FIGURE 1**). The 20 dB upper frequency limit of a Gaussian impulse (or Gaussian doublet) with a 0.5ns 50% width is ~1.75 GHz.

A series of experimental measurements of UWB propagation through two different 30cm-thick reinforced concrete walls was performed by Dr. John F. Aurand[4]. As shown in **FIGURE 2**, the summary was that "the attenuation constant (in dB/m) increases in a fairly linear fashion with frequency". In other words, the lower the frequency, the greater the penetration.

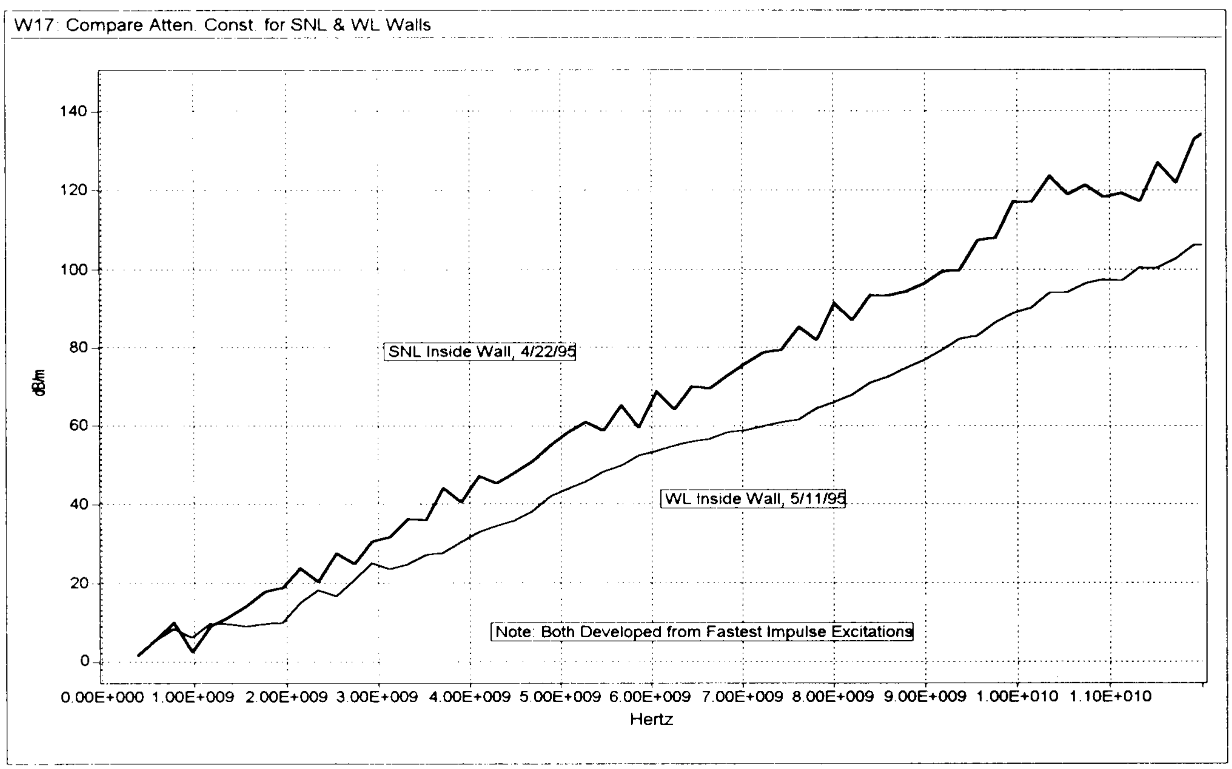

FIGURE 2. Attenuation constant for propagation of UWB impulse through 30cm-thick reinforced concrete walls at Sandia and Wright Laboratories.

[4] John F. Aurand, "Measurements of Short-Pulse Propagation though Concrete Walls", *Ultra-Wideband, Short-Pulse Electromagnetics 3*, Edited by Baum et al., Plenum Press, New York, 1997, pp. 239-246.

Paragraph 15:

We agree with this estimate of operating range (30 meters). Longer range communication can be achieved by store and forward of packets within a network of transceivers. Using multiple hops reduces the signal power and therefore the potential interference of a UWB signal in comparison with traversing the same distance in a single hop. This follows from the reduction of signal strength as the inverse square (or worse) of distance. The tradeoff is longer latency, but this is not a problem for the localization and low data rate communication applications that we project.

Using multi-hop store and forward of packets for longer range communication also has the advantage of reducing interference and increasing the covertness of the communication channel. If UWB transceivers are sufficiently small, light, and low power, then they could be dropped like bread crumbs to set up inexpensive and instant infrastructure. We think of this example as an "aether wire".

Paragraph 18:

We agree that "near-term applications for UWB technology involve relatively low powers and short operating ranges". Also note that many applications will require battery powered UWB devices to operate unattended for upwards of a year or more. Such extremely low power can be achieved using short (~10 μs) very low duty cycle episodic transmissions. This mode of operation further reduces the potential for interference from a Part 15 UWB device.

Paragraph 21:

Defining a UWB device using the 10 dB versus 20 dB bandwidth requires the device's bandwidth to be wider in order to qualify as UWB. We have no problem with this, as the fractional bandwidth of our signal approaches 200% using the $2(f_H-f_L)/(f_H-f_L)$ formula.

We agree that the "bandwidth be determined using the antenna that is designed to be used with the UWB device". Especially in UWB devices, the antenna is an integral part of the system, greatly affecting the radiated signal's bandwidth and phase response. Any other antenna will likely produce different results than were originally tested.

Paragraph 23:

We join with the others who have commented that UWB systems cannot avoid transmitting within the restricted bands.

We disagree with the U.S. GPS industry council that UWB operation should be limited to spectrum well above 1610 MHz. The key advantage of UWB is bandwidth at low frequencies, where the signal can penetrate walls and the devices can be made inexpensively using CMOS circuits. Rather than confining UWB transmissions to be above 2 GHz, the FCC should set reasonable levels for emissions within the GPS bands (consistent with the noise sources that already exist). Then manufacturers could choose how they can meet these limits.

We agree with those opposed to the use of filters to avoid operation within certain restricted bands. We also agree with Time Domain's assessment of the negative consequences for UWB systems of <u>band-reject</u> filters. However, there are several options for avoiding the GPS bands which are illustrative of what manufacturers could do. An outright ban on UWB operation below 2 GHz would be dictating a political solution to an engineering problem and would favor some UWB systems over others. We disagree with MSSI and Interval that UWB operations should be confined to frequencies above 2 GHz or in the 2.9-4.99 GHz band.

To limit radiation in the GPS bands, any UWB device using a baseband signal has the option of rolling-off its signal in the frequency domain above 1 GHz by shaping the impulses it radiates in the time domain. Our UWB localizers do this. The Æther Wire system also has the option of placing nulls in the spectrum of its radiated signal at both of the GPS frequencies. Our system transmits Pseudo-Noise-coded sequences of Gaussian "doublets". Each doublet (*i.e.* spread spectrum chip) is a positive Gaussian impulse followed by a negative Gaussian impulse or vice versa. The spectrum of our signal has nulls at multiples of the frequency given by the inverse of the separation between impulses. If the separation between impulses is chosen to be 5.707 ns, for instance, the signal spectrum has a null at 1576.9 MHz, which includes the L1 frequency of 1575.4 MHz, and another at 1226.5 MHz, which includes the L2 frequency at 1227.6 MHz (**FIGURE 3** and **FIGURE 4**). The 20 dB width of the notches depends on jitter, but can be up to 80 MHz wide at 1576.9 MHz and 40 MHz wide at 1226.5 MHz.

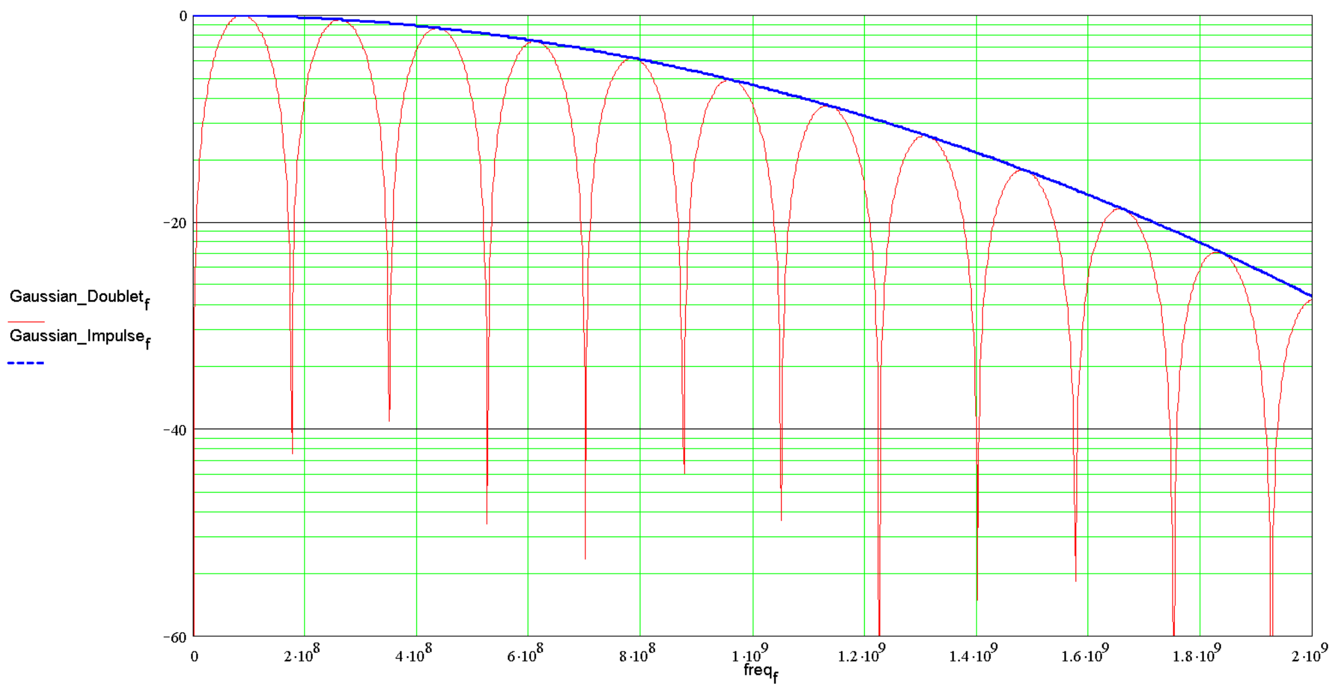

FIGURE 3 Spectrum of a Gaussian impulse (blue) with 0.5 ns 50% width and the spectrum of a Gaussian impulse doublet (red).

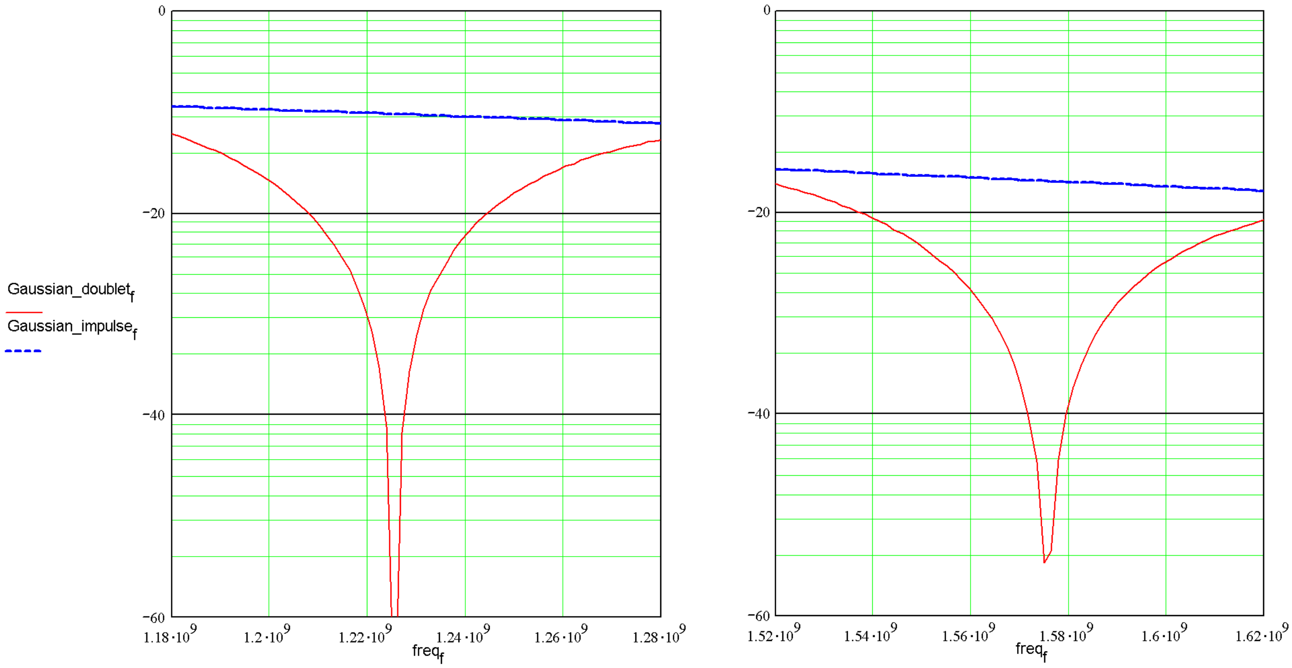

FIGURE 4 Details of the spectrum of a Gaussian impulse (blue) with 0.5 ns 50% width and the spectrum of a Gaussian impulse doublet (red) with separation chosen to place nulls at the GPS L2 ($1.2276 \cdot 10^9$ Hz) and L1 ($1.5754 \cdot 10^9$ Hz) frequencies. The 0 dB reference is the peak amplitude (at 0 Hz) for the Gaussian impulse.

Paragraph 26:

As noted above regarding the "Applications and General Characteristics" section, we believe that *Localization* is the category which has the greatest number of future applications for UWB and the greatest need for its unique characteristics. Localizers, which are UWB transceivers that use cooperative ranging for position determination, absolutely need to operate through walls, floors, and other obstructions. Otherwise, vision could be used, and the advantage of using RF would be lost. Resolution to within 1 cm is also very important for many consumer/commercial applications, such as gesture control, auto-focus, robotics (pick'n'place), etc.

In comparison to radar-based through-wall imaging devices, Localizers require much less radiated power for a given distance. The reason is that the strength of the return signal from a radar reflector diminishes at best as $1/r^4$, where r is distance, whereas the signal sent between Localizers diminishes as $1/r^2$. Localization needs bandwidth at low frequencies for penetration and resolution.

UWB Localization devices should not be restricted from using low frequencies, the same as for GPR devices, and they could use much less radiated power than radar devices.

Paragraph 27:

Since we believe the vast majority of applications for UWB technology fall within the category of *Localization*, we disagree with the statement that "most other applications for UWB technology could operate in a variety of regions of the spectrum". Our comments above regarding Paragraph 13 point out the importance of the low frequencies (< 1 GHz) for UWB *Localization* devices whose signal needs to penetrate walls, floors, and other obstructions. Of even more importance is the impact on the device cost that comes from being able to use low frequencies. Cost will be an overriding factor in the ability of UWB devices to succeed in most applications.

Low cost, small size, and low power can all be obtained by integrating UWB devices in CMOS. This includes driving the transmit antenna directly from the chip without any expensive and bulky inductors, filters, transmission lines, or other microwave "plumbing". With this configuration, a UWB device can transmit a Gaussian impulse by driving the Transmit antenna with a Gaussian edge (*i.e.* the radiation is proportional to the derivative of current). Of necessity, the voltage across the antenna terminals has to be restored to zero, but not immediately. If, after a measured delay, another Gaussian edge is used to zero the antenna voltage, a second Gaussian impulse of opposite polarity will be radiated. The spectrum of a single Gaussian impulse is a Gaussian shape centered at zero frequency. The spectrum of two Gaussian impulses of opposite polarity (a "doublet") has a Gaussian-shaped envelope with nulls at zero frequency and multiples of the inverse of the impulse separation. The important point is that the UWB signal which can be generated directly and effectively by a low cost CMOS chip has a spectrum which is predominately below 1 GHz. (For more details, see Technical Abstracts from 1997 proposal to DARPA at http://www.aetherwire.com/Aether_Wire/Technical_Abstracts_97.pdf)

To radiate a UWB signal with frequencies below 1 GHz requires using a UWB antenna with a matching low frequency response, of which there are several. If an antenna with a "resonant frequency" were used, then a damped oscillation would be radiated – possibly as short as one cycle. Whether one or more cycles are radiated, the separation between the first half cycle and the second half cycle is determined by the lower frequency limit of the signal. The same is true if the lower frequency limit is set by the antenna or by a filter in the signal path. This separation between the first half cycle and the second half cycle directly impacts the cost of a UWB *Communication* or *Localization* device. The reason is that the separation determines the stability and accuracy of the timebase for generating the reference against which the received signal is correlated.

The stability and accuracy of the timebase impacts the cost, size, and power of the UWB device. If better than ~1 ppm stability and accuracy is needed, then an ovenized crystal oscillator (OXO) is required, as opposed to a temperature compensated crystal oscillator (TCXO). An OXO is typically an order of magnitude more costly than a TCXO (> $100 versus < $10). Ovenized crystal oscillators are also many times larger and more power consumptive.

Paragraph 28:

This paragraph notes that "GPS may be used by commercial mobile radio E-911 services to enable police and fire departments to quickly locate individuals in times of emergency". The regulations for E-911 services using GPS require localization to within 100 meters, 67% of the time. This performance level does not solve the entire problem of locating individuals in times of emergency. At best, this can help to locate the individual within a building. However, using UWB Localizers, along with the primary E-911 device, will make it possible to locate the individual to the last meter.

Paragraph 29:

Regarding "potential restrictions on operation for UWB below 2 GHz, and the impact such restrictions would have on any potential applications for UWB technology": We are opposed to additional restrictions on operation for UWB below 2 GHz beyond the spurious emissions limits set forth in 47 C.F.R. Section 15.209. The bandwidth below 2 GHz is precious in the sense that it is the most useful for making low cost devices that can provide position location and low data rate communication in homes and buildings. For communication alone, bandwidth is more freely available above 2 GHz, and narrowband RF can use wider bands for higher data rates. Moreover, heterodyne conversion is a proven and effective technique for using narrowband RF at microwave and millimeter-wave frequencies. Also, resonant (*i.e.* narrowband) antennas are smaller at higher frequencies. In fact, a case can be made that narrowband / high data rate communication should migrate to higher frequencies, and that the lower frequencies should be reserved for localization and low data rate communication.

Paragraph 30:

Regarding the "viability of establishing a general emission limit for UWB devices below 2 GHz": Current Class-B levels work even with thousands of PC's and PDA's in an office building radiating at the Class-B limit. UWB devices that meet the same emission levels should be allowed.

Paragraph 34:

Regarding question 3) "What is the potential for interference due to the cumulative impact of emissions from multiple transmitters": UWB *Localization* devices operating as part of a network can and will use Time Division Multiple Access protocols to disperse their episodic transmissions to avoid collisions. In other words, a network of UWB *Localization* devices within a volume small enough for them to communicate will have only <u>one</u> device transmitting at any one time. Therefore, there is no cumulative impact of emissions from networked Localizers.

Paragraph 35:

We agree with those who suggest that "the Commission should adopt the same emissions limits for UWB devices as already exist for <u>unintentional</u> radiators". We strongly disagree with those who argue that the FCC "should apply the general emission limits for <u>intentional</u> radiators" for UWB devices, because this would allow only spurious emissions in the restricted bands per Section 15.205. As recognized in Paragraph 23, "the majority of UWB systems cannot avoid transmitting within the restricted bands".

We concur that "if the PRF is less than the receivers bandwidth, the UWB signal may appear to the receiver as impulsive noise". We note that any test of the interference from a <u>simulated</u> UWB transmitter should use a PRF that is very low (~1 KHz) or above the bandwidth of any possible victim receiver. To illustrate that UWB devices with a high PRF are possible, we note that our system uses a 200 MHz PRF.

Paragraph 36:

We agree that "it may be possible for designers to select system parameters to avoid GPS signal bands". By adjusting the space between the impulse doublets that we radiate and the spacing between the impulses in each doublet, we can in fact put <u>nulls</u> in our emission spectrum at the GPS bands. See the discussion above regarding Paragraph 23 for more details. This approach has limited degrees of freedom, but it works quite well with the L1 and L2 GPS frequencies, which are approximately related by a 9 : 7 ratio.

For *Localization* devices using cooperative ranging within a network of UWB transceivers, there is no incremental "cost implication of using a stable frequency reference". Such devices presently only need a temperature compensated (<u>not</u> ovenized) crystal oscillator (TCXO) with ~2 ppm accuracy. TCXO's with this accuracy are relatively inexpensive thanks to the proliferation of cellular phones. For very lost cost devices, the temperature compensation can be integrated on the CMOS transceiver chip. These assertions only apply if *Localization* devices are allowed to operate below 2 GHz. See the discussion above concerning Paragraph 27 for the cost consequences of restricting operation of UWB devices below 2 GHz.

Paragraph 37:

The sentence "For UWB communication systems, the emitted spectrum depends on the information being sent", is not true for a UWB system which uses a PN (pseudo-noise) code for channelization, such as ours. For these systems, the spectrum depends on the shape of the chip waveform (*e.g.* a Gaussian impulse doublet) and the coding for channelization and process gain – not on the data. We believe that a UWB system which lacks coding for channelization is severely limited in its capabilities, and this is the only system for which scrambler technology is applicable. Thus, we contend that "a performance requirement that would show that the transmitted spectrum remains noise like in the case of unchanging input data" is appropriate.

Paragraph 39:

We agree that "the general emission limits contained in 47 C.F.R. Section 15.209 appear appropriate for UWB operations", with the proviso that UWB devices be included in the exemption for intentional radiators of paragraph (d) of section 15.205. We disagree with the proposal that "emissions that appear below approximately 2 GHz be attenuated by at least 12 dB below the general emission limits". We believe that the Part 15 general emission limits have indeed had "a long and successful history of controlling interference to other radio operations", and that emissions from UWB systems have comparable interference potential to other Part 15 devices, especially UWB devices with very low duty cycles. We feel that a blanket reduction in emission limits will hurt the functionality of UWB devices without reducing interference.

Our objection to a 12 dB reduction in emission limits below 2 GHz notwithstanding, UWB devices which use a baseband signal can roll-off their emission spectrum above 1 GHz to avoid the GPS bands. (Devices with resolution finer than ~1 cm would need more than 1 GHz of bandwidth.) See the comments above concerning Paragraph 23.

Paragraph 43:

We assume that the proposed limits on peak level set forth in this paragraph only apply for emissions above 1 GHz. This assumption is based on the first sentence of Paragraph 42 and the fact that the average level is used in the formulas for setting the peak limit, which normally only applies above 1 GHz. We further assume that the required use of a CISPR quasi-peak detector for measuring emissions below 1 GHz accounts for all the intended restrictions on peak level. In any case, the Commission should be clearer as what is actually proposed.

Paragraph 46:

We agree that "a proliferation of UWB devices would have a negligible impact on the background noise level", based on our own simulations of aggregate effects. In addition to the arguments given in response to the NOI, there is a reason this is true for UWB *Localization* devices operating as part of a network. Specifically, UWB *Localization* devices can and will use Time Division Multiple Access protocols to disperse their episodic transmissions to avoid collisions. In other words, a local network of UWB *Localization* devices will have only one device transmitting at any one time.

Paragraph 54:

Farr Research sells calibrated UWB antennas / TEM sensors that have no phase dispersion and a flat frequency response from about 100 MHz to 8 GHz. See their catalog at http://www.farr-research.com/cat/tem.htm.

Exhibit I – Applications which Require UWB Below 2 GHz

Public Service and Safety

Fireman Buddy System – Policemen and firemen often need to go into dangerous situations. Incapacitation out of sight of their comrades is a life-threatening situation. Policemen and firemen can have Localizers so they can be tracked during dangerous operations.

Home Navigation System for the Blind – Localizers can set up a virtual path through doors and a virtual fence around furniture. One rover is needed on the blind person and base stations can be set up around the house.

Handicapped / Learning Impaired Tracking System – Instrument all children so that they are warned not to stray into danger areas, and also warn caretakers. Each handicapped child has a Localizer. When they get into dangerous areas, they get an audible warning. In addition, a central monitoring facility can also get a warning and send a staff person to help the child.

House Arrest Monitors – Parolees, probationers and people under house arrest need to have their actions monitored. A system to keep people under house arrest or at home during curfew hours can be set up similar to the pet sitter or child locator system. A master Localizer is hooked up to the phone. A rover unit is placed on the parolee. The other units are nodes that are installed around the house.

Automobile Collision Avoidance System – Vehicles driving too close are a major source of accidents. Reducing spacing between vehicles increases the carrying capacity of our highways, but increases collision risk. Localizers on each car (all four corners) can warn the driver or automatically slow and apply brakes when it gets too near another car with Localizers. The system can also be used to warn drivers approaching a "blind" curve, indicate if the vehicle is going the wrong way down a one-way street, track a stolen vehicle, or help the owner find his car in a parking lot.

Waterway Markers (Electronic Buoys) – Coastal navigation and waterway markers should readily identify themselves, be low cost and low maintenance. Localizers on buoys and other channel markers can be used for channel and coastal waterway navigation. Each one has a unique identifier.

Fault Line Detection – Detect movement along a fault line or in a cement pour. Sensor communication in these applications must be extremely low power to operate unattended for long periods of time.

Consumer

Child Finder – Parents need to know where their children are, especially between the ages of 2 and 5 when children have mobility without judgement. One rover worn by the child and one master unit for the parent are needed. Also a virtual fence can be set up in the home. Other non-UWB attempts at this problem, typically using a simple RF signal strength, give an indication of distance, but not direction.

Virtual Fence for Pets and Livestock – Pet owners want to be able to keep their pets within set confines on their property without the expense and unsightliness of a complete fence. One rover is worn by each pet and the owner has a master unit. A Virtual Fence is set up for the rover.

Sports Coaching System – Sports trainers and coaches need a way to give feedback to their trainees about how they are performing or using their sports equipment. Instrument the player with multiple Localizers to determine things like swing and form (e.g. for golf or tennis). In a similar way, Localizers can be used by the umpire/official to indicate when an infraction has been made (*e.g.*, out of bounds).

Passive Keyless Entry Systems for Homes and Car – Ideally, home security systems provide good security, but allow easy access for authorized people. One unit is carried as a key fob. As the user approaches his home, the door unlocks. To him the home or car is always unlocked, but to anyone else, it is protected.

Never Lost Products – Many items like keys, handbags, wallets, etc. are easy to misplace or lose. A Localizer is put on purse, wallet, keys, luggage, golf balls, etc. A Localizer on your person (like a wristwatch) can be set to give an alarm if your wallet or handbag goes beyond a certain radius.

Smart-Home Monitors – Localizers can be used to monitor temperature, power usage, etc. They can also control when to turn on the furnace and which room needs to be heated and illuminated.

Industrial

Mining Equipment Tracking Systems – Equip all mine workers, trucks, carts, and other equipment with Localizers.

Museum Guide – This would be an automated tour guide that you carry with you. It also keeps track of children. A museum can be instrumented for a nominal charge and Localizers rented out at the museum entrance from a dispenser. The Localizer is returned to the dispenser when the patron leaves the museum. Localizers are very hard to steal. This can be combined with an electronic tour guide that gives auditory instructions, explanations and warning, all depending on location within the museum. These systems can also aid in security and traffic monitoring. Also applicable to an amusement park.

Virtual Reality Sensors – Virtual reality sensors need to be inexpensive and reliable to make the systems viable. Localizers can be mounted on head and limbs to track movement and location.

Motion pictures – Automatically adjust camera focus and motion-tracking for matching digital effects.

Government/Military

Roadway Edge Markers for Snowplows – In high snow areas, it’s hard to determine where the edge of the roadway is for proper snow-plowing. Localizers are placed along the roadway in high snow areas. They provide the driver with a precise guide for the snowplow.

Military Vehicle and Personnel Location Systems – Field commanders often don't know the location of their personnel and equipment. This leads to operational inefficiencies and, in wartime, friendly fire casualties. Localizer systems installed on all military equipment and personnel will allow tracking for command and control, for after-action reports on war-games and for IFF (Identify Friend / Foe). They could also keep track of mines, armaments, equipment, vehicles, etc.

Emergency Equipment Markers – A problem for fire-fighters is locating the nearest fire hydrant or other emergency equipment. Localizers are placed on fire hydrants and emergency equipment and firefighters can locate them quickly and efficiently.

Asset Tracking/Inventory Management

Sea-Tainer Tracking Systems – A Localizer is placed on every sea-tainer as it comes into a port or station. The Localizers can be used to conduct a virtual inventory count and also to guide the container’s movements (*i.e.*, make sure the right container is loaded onto a truck or train).

Volumetric Inventory Control Systems – Warehouses and manufacturing plants need to know the size and makeup of their inventory, especially with large, high-value items. Localizers are placed on each piece of inventory that needs to be tracked. Location and identity of each item can be called up from a central database.

Hospital Equipment and Personnel Location Systems – A problem in hospitals is locating critical pieces of equipment and personnel. Since many of these pieces of equipment are mobile, they are sometimes placed in the wrong room. A Localizer can be placed on every patient, health care provider, and piece of equipment so that critical equipment and personnel can be located very quickly in an emergency.

Library Book Locator – Libraries need to be able to control their inventory (books). They need to prevent theft but make legitimate use easier. Localizers are placed in the spine of each book. No more need for the Dewey decimal system or refiling returned books. Just look up the book you want in a database and the finder system takes you to it.

Exhibit II – UWB Companion Applications to Narrowband Communications/GPS

E-911 "Last Meter" – E-911 services using GPS require localization to within 100 meters, 67% of the time. At best, this can help to locate the building that the individual is in. However, a companion 3D positioning technology, which is possible with UWB Localizers, can help locate the individual to the last meter.

Small Sensor Communication – Connect everyday objects in the home onto the Internet for communications and control.

Information Spigot for the Wireless Web – Advise wireless Internet service provider of your location so that it can prepare to download your high bandwidth information (emails and messages) when you are near an "information spigot".

Ground Guidance for Airplanes – Establish the airport runways, taxi ways, and terminals on a UWB grid so that exact 3D position and presence of all aircraft in the airport is available for the control tower and pilots. This can augment GPS use in the air.

Aiming Lasers and Directional Antennas – Lasers can be used for very power-efficient high data rate communication if aimed directly at a receiver. UWB position location can be used for mobile receivers.

Synthesis of Large Aperture Antennas – Transceivers scattered about that know their precise relative location and synchronization can synthesize a large aperture antenna for tight beam communication.